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FARMERS' BULLETIN No. 1319

# COTTON DUSTING MACHINERY

DUSTING COTTON PLANTS with powdered calcium arsenate has proved to be the most economical and successful method of poisoning the boll weevil on a commercial scale. Success, however, depends largely on the use of suitable dusting machinery. This bulletin tells the prospective buyer how to select a type of dusting machine suited to the conditions and needs of his own farm, and one that should prove efficient and durable if given proper care. It supersedes Farmers' Bulletin 1098, Dusting Machinery for Cotton Boll Weevil Control, published in 1920.

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# COTTON-DUSTING MACHINERY.

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## DEVELOPMENT OF MACHINERY FOR COTTON DUSTING.

WITH the establishment of the calcium arsenate method of control for the cotton boll weevil it has been necessary to develop a practically new industry—the manufacture of machinery that will apply this insecticidal dust to cotton in the manner required for successful results. Poisoning of cotton on a commercial scale was begun about 1917, and by the fall of 1919 enough knowledge of cotton-dusting machinery had been acquired to warrant a publication on the subject.[1] As much progress and rather radical changes along this line have been made since then, however, the present bulletin has been prepared so that all information to date may be available.

At the outset it was realized that specialized machinery was a necessity and that no other could be expected to yield successful results in dusting cotton plants. Years of experience in commercial poisoning have emphasized this necessity, and some of the most glaring failures have resulted from the use of makeshift apparatus. When cotton dusting was first undertaken, practically the only dusting machinery manufactured was that for treating truck and orchard crops. These machines were altogether unsuitable for use in the cotton field. Furthermore, the area infested by the boll weevil was so great and included such diverse conditions of cotton culture that a detailed study was required to determine the bearing of these conditions on the suitability of various types of dusting machinery. No one type has been found adaptable to all conditions, consequently an effort has been made to classify these conditions with special regard to the type of dusting machinery needed and to develop suitable machinery as rapidly as possible, priority being given to

[1] Farmers' Bulletin 1098, United States Department of Agriculture, January, 1920.

those districts that have seemed to require and deserve the earliest consideration. In this way various models of dusting machines have been developed step by step.

A mechanical division of the Delta Laboratory of the Bureau of Entomology, Tallulah, La., was organized at an early stage of the work and has been continued. This organization aims to develop new types of dusting machinery and to test and improve existing models. Several distinct types have been designed, constructed, and tested at the Delta Laboratory, and, when carried to a point of reasonable perfection, detailed descriptions and specifications have been furnished all interested manufacturers. Furthermore, any new developments of a fundamental nature are patented by the laboratory engineers and dedicated to the public, so that anyone may utilize, but not control, these features. Numerous manufacturers have modified these designs to conform to their methods of production, and their tentative models have been subjected to elaborate series of tests by the Delta Laboratory engineers, so that these machines may be perfected in every way possible before they are offered for sale. Undoubtedly these two lines of endeavor have not only aided in increasing the variety of machines available, but also have done much to increase their initial efficiency when placed on the market.

As was to be expected, some models developed in the earlier days have been discarded in favor of better equipment. Four years ago not a dusting machine on the market was suitable for treating cotton; now there are nearly 40 models, manufactured by over 20 manufacturers, and many more are being developed. The cost of these dusters has been somewhat high in the past, as is the case during the development of any new and complicated machine, but several have now become fairly well perfected, so that manufacturers can undertake quantity production. This will undoubtedly greatly reduce the cost. Furthermore, in the past it has been necessary to include in the price of these machines a rather heavy charge for salesmanship because of the pioneering effort necessary in introducing a new implement. This stage is now passing rapidly, and the cost of selling a dusting machine is decreasing sufficiently to permit a price much closer to the cost of manufacture. Even now these machines are much more reasonable in price than they were a year or two ago, and further reductions may be expected.

Other publications[2] furnish general instructions for poisoning, but certain principles involved in the process of dusting cotton influence the design of the machines and must be taken into consideration. These will be noted from time to time throughout this bulletin. One very important point, however, should be mentioned here. For successful dusting a time interval of hardly more than four days between poison applications has been found necessary as a general rule. Practical experience in the operation of the machines has shown that a certain allowance must be made for loss of time throughout the dusting period caused by unfavorable weather conditions and other circumstances. In all computations relative to the acreage capacity of any dusting machines, therefore, a 25 per cent loss of time has been included, and the seasonal acreage capacity of

[2] Farmers' Bulletin 1262 and Department Circular 162.

any one machine is rated as approximately three times its daily capacity. In other words, it will be able to treat this area every four days and still allow the loss of one day out of the four from some cause.

## HOW TO SELECT DUSTING MACHINERY.

The first problem before the farmer planning to poison is the selection of equipment suitable for his particular conditions. Machinery can now be obtained to meet almost any condition, and the success of the whole dusting operation depends very largely upon choosing the right machine. Some of the more important points to be considered in deciding this matter are discussed in the paragraphs following.

### CHARACTERISTICS OF FARM.

The size both of the individual fields or "cuts" and of the entire farm have a bearing on the size or type of machine to be used. Of course, the first question to be decided is whether the property is to be treated as a whole or whether the individual fields are to be regarded as separate units. In many portions of the Cotton Belt the crop is raised under the share tenant system. Some owners desire to buy large dusting machines with which to treat the entire property, regardless of tenant lines; others wish to purchase machines for each tenant, and naturally desire machines adapted to the acreage of the tenant. Under the discussion of machine types will be found an outline of the acreage capacity of each machine.

Other factors, however, may influence the selection of a machine more than the acreage of the field. If the dimensions and shape of the field are such that the rows are short, or if ditches, fences, or terraces make frequent turnings necessary, or if stumps and logs are present and must be avoided, the best machine will be one that can be turned easily and with the least damage to the cotton plants. For operation on rough, sloping hillsides, or heavily terraced land, where a machine on wheels might tip over, the type best adapted to avoid this difficulty must be chosen. Either hand or saddle guns can be used on such land without being placed at a disadvantage, but any machine mounted on wheels, to work under such conditions, must be well balanced, the weight placed as low as possible, and support against side-tipping provided by the animal, the driver, or both. If a machine operating entirely between two rows is considered for use under such conditions, one should be selected with the width between the wheels as narrow as possible or mounted on a single wheel, because this will reduce the tendency to tip over and will make the machine much more easily handled. Generally speaking, the two-horse or "cart" machine is more difficult to handle under these conditions, and is frequently altogether unsuitable because the width of its tread is fixed by the width of the cotton row, and its entire load is placed above the arched axle, thus making it top-heavy.

The method of cultivation is also important. The ridged type practiced in some districts makes it very difficult to operate any machine with two wheels running in a single middle, whereas this wheel arrangement is quite practicable in a field cultivated flat.

In planning to poison the farmer should, therefore, consider carefully the characteristics of the land he is going to treat. In many cases, on the larger farms, it will be necessary to purchase several different types of machines for a single property, using the larger, more rapid machines for the areas for which they are suitable, and providing other types to treat the remainder.

### SUITABILITY OF MACHINE FOR LABOR AVAILABLE.

In selecting a dusting machine the farmer should consider who is going to operate it. On some farms there will be men who have had more or less mechanical training and who can operate the more complicated machines to better advantage than could the average cotton-farm laborer. Manufacturers are striving to build machines as simple in construction and operation as possible, but some machines are more complicated than others, and, as a result, require more skillful attention for their proper operation and upkeep, although this additional requirement may be counterbalanced by a corresponding increase in the speed and efficiency of dusting. One of the first machines developed was of a very large type, the dusting machinery of which was operated by a gas engine. Although largely abandoned, because of the inability of the average laborer to operate the complicated equipment satisfactorily, some machines of this type have been used for several years by comparatively skilled individuals with excellent results. The selection of a machine, therefore, should be governed to a certain extent by the class of labor available for its operation. Furthermore, in different districts laborers of the same class will have different ideas regarding certain points in the operation of the machine. For example, in some localities where riding cultivators are used extensively and the labor is thus not accustomed to walking implements, it is difficult to secure satisfactory operation of the one-mule type of machine, which requires the operator to walk, although in other districts this objection is not encountered. Then, too, in some places the average laborer objects strongly to wetting with dew, believing it prejudicial to his health, and under such conditions the use of hand guns has never proved really successful. It is to meet this objection that many of the one-mule machines are provided with shields which prevent the dew-laden plants from coming in contact with the operator.

The conditions under which the operator of the dusting machine has to work are not pleasant at best, and every effort should be made to secure a machine that will not impose an undue amount of work on him and the use of which will be as easy, simple, and comfortable as possible. With some types of machines the operator is forced to be in contact with the dust cloud at times, but whenever possible the nozzles should be so placed that the man has a minimum exposure to the dust cloud. Although under ordinary field operating conditions the poison dust is not injurious to human beings, if ordinary precautions as to cleanliness are taken, no one wishes to breathe it continuously or to have the skin coated with it.

This question of suitable labor for operating the machines enters into the problem in another way. As has just been mentioned, on the larger properties it is frequently necessary for the owner to

decide whether the entire property shall be treated as a unit, or whether the individual tenants shall be provided with dusting machines adapted to their individual acreages, and each tenant required to treat his own crop. If the tenants are to do the work, only the simplest machines will be suitable, whereas, if the poisoning is to be handled by a force organized separately, it may be possible to secure individuals who can operate the larger machines; and, generally speaking, this separate organization for dusting will be found more efficient and profitable.

## DAY OR NIGHT OPERATION.

The time of day or night when poisoning is to be done also has an important bearing on the type of machine to be used. **Dusting should be done when the air is calmest, whether it be during the**

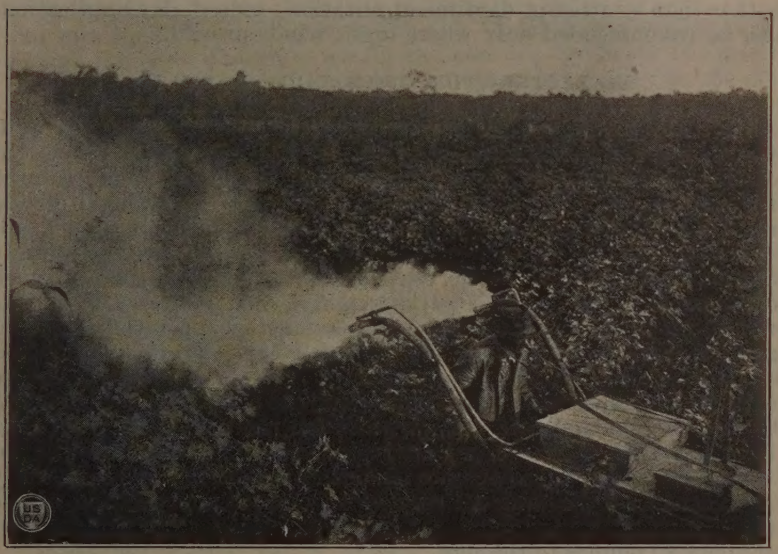

FIG. 1.—One-mule machine in operation, showing approved method of blowing dust downward through top of cotton plants toward the ground.

**day or at night.** As the presence of dew on the plants at night causes the poison to adhere to them better, and as night is usually the time of least air movement, this is the time when most poisoning is done. In some localities, however, trade winds blow during the night and the air is calmer during the day. Under such conditions the calmest portion of the day should be selected for the dusting. It is exceedingly important that the air be calm enough so that the dust cloud can be blown down through and among the cotton plants (see Fig. 1) and to permit the poison to settle over the plants.

Night dusting, of course, makes the work more difficult, and some machines which can be run easily in the daytime are unsuited for night operation. Night applications have to be made under artificial light, which is a poor substitute for daylight. The light itself

is more or less in the way and requires some attention. It is more difficult at night to watch the operation of the machine and to anticipate difficulties, and the repair work becomes much more complicated and troublesome when undertaken at night. Driving is more difficult, especially where stumps, logs, ditches, or other obstructions are shaded or hidden among the plants and weeds. In addition, the presence of the dew on the plants makes it necessary to provide some portions of the machine with suitable shields or guards, to prevent this moisture from entering and interfering with operation. As has been mentioned, the contact of the operator with the dew is also sometimes a complicating factor, and whenever possible machinery should be selected for night use that will provide the maximum amount of protection for the user.

In spite of all these difficulties attending night operation, however, it is almost always better to overcome them and to dust at night rather than to attempt daytime application; indeed, day applications can be recommended only where night winds prevail.

## CHARACTERISTICS OF CALCIUM ARSENATE.

**Only dry powdered calcium arsenate is recommended for boll-weevil control,** and the characteristics of this material are such that dusting machinery of special design and construction is required for handling it. Whenever possible, a prospective purchaser should require a demonstration of a machine, to assure himself that it will distribute the poison properly. Calcium arsenate is exceedingly fine and inclined to be sticky, especially at night when there is much moisture in the air. As it packs quickly when subjected to a little vibration, agitators or stirring devices must be provided to guard against this and to insure a uniform delivery. Every dusting machine is equipped with some sort of a feeding device intended to regulate the amount of poison blown into the air. This device should be so constructed that it will give an even rate of discharge of dust for any period of time at any setting of the feed gauge, and will not clog or otherwise fail to operate under any condition. It is especially important that the dust delivery be regular at any position of the feed-adjusting lever, from complete cut-off to a maximum feed of about 25 pounds to the acre.

The amount of poison the hopper will hold at one filling is a matter of great importance, for it is very desirable to reduce as much as possible the frequency of filling the hopper without unduly increasing the weight or size of the machine. The volume of different brands of calcium arsenate varies somewhat, but the standard types range between 80 and 100 cubic inches to the pound; if, therefore, the dimensions of the hopper are known, its approximate capacity can be computed in pounds.

In examining a machine with a view to purchase, the farmer should remember that this sticky quality of calcium arsenate is dangerous from the time the material is put in the hopper until it is blown out of the nozzle. He should therefore follow its course through the machine carefully and see that at every step due care has been taken to prevent packing or clogging, and that all parts handling the dust are readily accessible for cleaning. The distributing tubes and their

connections should be smooth inside, without any square corners to catch and hold the dust and without short bends to interfere with the free passage of the dust-laden air.

## TYPE OF DUST CLOUD REQUIRED.

A very important feature of the dusting operation is the method for bringing the poison in contact with the plants. Spraying is an old operation and nearly everyone is more or less familiar with it, whereas the use of dry or "dust" applications is more recent and less known. The two operations, nevertheless, are fundamentally the same. In spraying, the poison is mixed with water just as thoroughly as possible and distributed over the plants. In dusting, air is used instead of water, and the poison should be mixed with it just as thoroughly to secure as complete a distribution; consequently it is important to have a machine that will separate the particles of poison and mix them thoroughly with the air. A good way to test this is to pass the hand under the nozzle and note the condition of the dust as it is blown out. If the machine is operating properly, the dust will be thoroughly mixed with the air and broken up into the finest possible particles. If lumps or small pellets are found, these represent so much waste material and correspondingly reduce the effect of the poison.

One advantage of dusting over spraying is that the spray will not float in the air to any great extent, and it is necessary to depend entirely on delivering it directly on the plants. The most successful dusting operation, on the other hand, creates a cloud of dust behind the machine which fills the air like a fog, drifts among the plants, and settles upon them from top to bottom, covering every particle of exposed plant tissue. To secure such a dust cloud is comparatively easy under really favorable dusting conditions, when the atmosphere is calm and contains sufficient moisture to cause the dust to hover for a long time wherever it has been delivered; but such ideal conditions occur only occasionally and are not the average conditions under which the farmer must operate in dusting his crop; consequently the most valuable machine is the one that will thoroughly dust the plants under the most unfavorable conditions.

Since the poison has a greater tendency to blow away when released above the plants than when actually blown into the tops of them, and since it is also exceedingly important to dust the upper portion of the plants, regardless of how high they may be, a considerable range in the elevation of the nozzles is essential. In the case of the cart type of machine, or any other machine straddling the rows, the tops of tall plants are bent down to the level of the nozzles, and it is not essential that these be subject to elevation much above the level of the machine platform; but in those machines which run between the rows it is very important to have the nozzles subject to elevations ranging from 18 inches to about 72 inches.

Some machines have been so designed that, when the nozzles are elevated to their maximum height, they will swing so that the dust is blown out horizontally to the rear. Such machines will not do efficient dusting, and the nozzles should be so arranged that when they are elevated to their maximum height they will still deliver the dust

somewhat downward into the plants and thus prevent the breeze from blowing the poison away above the plants. Furthermore, the air blasts from the fan should be strong enough to force the dust cloud down through and between the plants to the ground from the highest elevation of the nozzles.

With some machines provision has been made for adjusting the distance between the nozzles so that these will fit different row widths, but, especially in machines of the larger type, this is of comparatively little importance.

In fact, except where two-row planters are used, the row widths vary so greatly in even a single field that it is impossible to keep the nozzles adjusted so as to put them directly over the rows. To meet this difficulty, the nozzles of many of the machines have been designed so that the dust-laden air is spread widely in a fan shape in leaving each nozzle, the clouds from the different nozzles thus uniting very quickly into a solid dust cloud extending across at least the width of the machine. In this way every particle of the plant is dusted, whether or not it is subjected to a direct blast from the nozzle.

Incidentally, it is exceedingly important that the farmer who is planning to poison shall know just what an efficient and thorough dusting of his plants looks like. Unfortunately, this is something which can not be visualized from mere verbal description, and even photographs fail to show the true appearance. The best suggestion is that everyone arrange to see one of the motion pictures which have been prepared to show the operation of dusting. These pictures were made by the Department of Agriculture and are available for free distribution in so far as the supply of sets of films will permit. They show the appearance and behavior of the dust cloud far better than words can describe them.

### DURABILITY OF MACHINES.

No farm implement can be considered a success unless it is sufficiently durable to meet every condition under which it is to operate. As a rule, operators of cotton-dusting machines know little about mechanics and often are more or less indifferent regarding the upkeep of any machinery as long as it continues to run. To be a success, therefore, a machine must be of sturdy construction and good materials, with all parts readily accessible for repair or adjustment. This need, of course, is accentuated by the fact that most of these machines are used at night, when a breakdown or any need of repair becomes a much more serious problem than it would be in the daytime. In addition, boll-weevil control is always an emergency operation. The weevils are not controlled by a single application, but by keeping the cotton plants poisoned continuously over a certain period of time, and any interference with this schedule may easily cause the loss of control and the failure of the entire season's operation. Under such conditions, the breakdown of a machine may be disastrous. It is economy, therefore, to pay a little extra, if necessary, and get a machine that is thoroughly strong and durable as an insurance against such a possibility.

In the past many machines have been built along somewhat the same lines of construction as those used for orchard and truck-crop

dusters, and when these were introduced into extensive field service under the conditions of continuous operation and rough handling encountered in the cotton fields, they did not last. Many broke down in less than a season, and others were ready for the scrap pile after operating a single season. There is no reason why the farmer poisoning his cotton should be forced to buy new dusting machinery every year, and the production of machines has now developed to the stage where the farmer can demand and secure a machine that will be just as durable as any other implement he has on the property. Formerly, the most that could be expected of any available hand gun was that it would last through a single season, but now there are models on the market that can be reasonably expected to last three or four years. The first large-type machines lasted only one or two years, but many of the present models undoubtedly will do satisfactory work for at least five years, if given a reasonable amount of care. The farmer should demand a machine which not only will give efficient service at the outset, but also will continue to give this service over a period of years.

## GENERAL CHARACTERISTICS OF DUSTING MACHINES.

Before discussing the different types of machines, it is well to point out certain fundamental characteristics which are found in all machines, a knowledge of which will aid in a more complete understanding of the different types.

The dusting machinery proper consists of a fan or blower, a dust container or hopper, and the feeding mechanism. The arrangement of this combination varies in machines of different makes, but the aim in all of them is to have a hopper that will hold as much poison as can be transported conveniently, a feeder that will regulate the dust discharge at any quantity desired, and a fan that will produce a blast or current of air sufficient to deliver the dust at the required points.

At present three different kinds of air currents are used in dusting machines: First there is the "velocity" current, in which the volume of air is comparatively small but moves at a high rate of speed; second, the "volume" current, in which a large volume of air moves at a moderate speed; and third, the "intermittent" current, in which the air current is produced intermittently, as from a bellows. The third type is unsuited to cotton dusting, since this operation demands a continuous flow of dust to produce the cloud. All really successful cotton-dusting machines are equipped with either the volume current or the velocity current.

Two different methods are used to move the dust to a point where it will be taken up by the air current. In one the dust is delivered by the feeder directly into the air line beyond the fan, while in the other the dust is fed into and through the fan either from the center of the fan or through the rim of the fan housing. Many claims are made by various manufacturers regarding the relative efficiency of these two systems. Those who feed the dust through the fan claim that the dust is broken up and better mixed with the air because of this fact; but, as far as present experience goes, there is apparently little or no choice between the two methods and both operate successfully.

There are many types of feeding devices; and, in fact, almost every model of machine has a device which differs somewhat from all others. Based on the fundamental principles involved, however, these feeders may be divided into comparatively few classes, and all tend to regulate the quantity of dust delivered and to carry or crowd it to a point where it is caught by the current of air. The following are some of the most common classes:

The brush feeds usually consist of some form of rotating bristle brush. They crowd the dust in front of the bristles and force it through an opening, the quantity going through being controlled either by changing the speed of the brush or the size of the opening.

The auger feeds usually operate by catching the dust in a spiral auger and forcing it along into the air current. They are regulated either by changing their speed or by changing the size of the opening which allows the dust to flow to them.

The whirling-disk feeds operate by throwing out by centrifugal force the dust which falls on them. They have a constant speed, and control of the quantity of dust is gained by varying the size of opening which allows the dust to flow from the disk.

The wire-cage or wiper feeds are found in a wide variety of shapes but are very similar in principle. They have some form of rotating or oscillating device which wipes or crowds the dust through an adjustable opening. These wipers are usually of constant speed and depend on the adjustment of the opening to control the dust delivered.

The air-blast feed consists of a blast blown from the fan through the dust hopper itself and depends on this blast to pick up sufficient dust to create a cloud. Its only adjustment is in either varying the rate of fan speed or by an adjustable deflecting blade throwing the air current more or less against the dust in the hopper. So far this type of feed has proved exceedingly unsatisfactory, since it has never been found possible to get a uniform rate of dust delivery throughout the various changes in the amount of dust in the hopper, and such a feed should be avoided in buying machinery for cotton dusting.

The plain-valve feed was one of the earliest types developed, but has been very largely replaced by the more efficient designs. In this class the quantity of dust delivered is controlled by varying the size of an opening through which the dust is supposed to flow by gravity into the air pipe. It has never been found possible to secure a satisfactory and uniform delivery of calcium arsenate when dependence is placed entirely on gravity.

Roughly speaking, these various feeding devices may be classed into the "forced" feeds and the "gravity" feeds, the gravity type depending on the material dropping down without assistance through some sort of an adjustable opening, while the forced feeds in some way push the material through the opening in a constant delivery. The forced type of feed has proved far more satisfactory in cotton dusting and should be secured whenever possible; in fact, nearly all manufacturers have abandoned the gravity type and it is encountered very seldom at present.

Another important consideration in connection with the feeder is the fact that it should be readily adjustable to any desired rate of de-

livery, from complete shut-off to about 25 pounds per acre, as based on the dust delivery from the individual nozzles. This wide range will enable the operator, when he becomes more familiar with the technique of poisoning, to increase greatly the area covered by giving a heavier feed, thus increasing the dust cloud formed and treating a larger number of rows than those actually spanned by his nozzles at each trip, advantage being taken of the drift of the poison through the plants beyond the rows over which he has actually passed.

For calculating rates of feed the following method may be used: For each pound of dust per acre, each nozzle should deliver at the rate of 0.015 pound per minute. Thus a hand gun having only one nozzle should feed at the rate of 0.075 pound per minute to deliver 5 pounds per acre, or 0.375 pound per minute to deliver 25 pounds per acre. The cart machine, having 3 nozzles, should deliver three times these amounts.

One type of feeder to be avoided is that which permits the dust to fall through into the air duct when the fan is not in operation. Some machines have been constructed which leave openings for the dust to be jostled through when they are not operating, and these have caused much difficulty, because this dust will fall through into the air passage and often clog this solidly before the fan is started, thus making it necessary to take the machine apart and clean out this passage.

The power for running the dusting machinery is furnished in the following three different ways, governed by the size and type of the machines:

(1) Hand-driven machines, in which the dusting machinery is turned with a crank by the operator. The hand and saddle guns are in this class.

(2) Traction-driven machines, in which the machinery derives its power from the traction wheels through chains or gears. The so-called one-mule and cart dusters are in this class.

(3) Engine-driven machines, in which a gas engine is mounted on the platform and connected with the dusting machinery, usually by a belt.

The relative characteristics of these different types of power will be mentioned in the following discussions of the various machine models.

## MACHINE TYPES.

As has been mentioned, there are many different models of machines, but these may be grouped into certain classes or types based on certain uniform characteristics. The following is a brief outline of these various types with a consideration of the capacity, advantages, and disadvantages of each type.

### HAND GUN.

The smallest type of dusting machine is the one that is carried by the operator and cranked by hand. The trade name "hand gun" has been very universally adopted to describe this type. It is usually constructed of sheet metal, with the hopper and fan housing either together or separated, and with a simple set of gears or chains for transmitting power from the crank to the fan, agitator, and

feeder. It is usually suspended from the shoulder of the operator by web straps, the method of strapping depending on the construction of the gun. Some are carried in front of the operator, resting on the abdomen, while others are carried on the side, resting on the hip. Experience has shown that the gun that is carried on the abdomen is usually the most comfortable to operate.

The weight and balance of the hand gun is a very important item. It should not only be sufficiently light to be carried without undue fatigue, but it should also be so balanced that the greater part of the weight will be as close to the body of the operator as possible and thus prevent any increase in the strain by leverage. For instance, the machines having the hopper of dust close to the operator are usually more easily carried than those with the fan housing intervening and the dust hopper farther forward, as guns of this latter type increase the pull on the shoulder straps. The weight of a hand gun with the hopper full of dust should not exceed 20 pounds, as this is all that can be carried without overburdening the operator. The hopper capacity of the various hand guns on the market ranges from 2 to 7 pounds of poison, and it is, of course, desirable to have it as large as possible without making the gun too heavy.

Several manufacturers have attempted to develop a hand gun with a bifurcated delivery line leading to two nozzles, for the purpose of dusting two rows simultaneously. These efforts, however, have been unsuccessful so far, since it has proved impossible to secure sufficient air blast to dust two rows thoroughly within the weight limitations of a hand gun. In so far as present machinery is concerned, therefore, no one should attempt to treat more than one row at a trip with a hand gun.

The rate of operation of a hand gun will, of course, depend largely on the endurance of the operator. As a rule, the average operator will be able to dust 1 acre an hour for the first hour or two and will then decrease rapidly in speed, until a rest is necessary after about three hours of operation. For this reason hand-gun operation is usually so organized that the dusting is done from daylight until about 8 or 9 o'clock in the morning, and then an additional hour or two is put in just before dark in the evening. In this way it has been found that an operator with one gun can take care of about 8 acres of cotton for the season. On the whole, it has been found that the hand gun is the least satisfactory of the various types of dusting machinery, primarily owing to the difficulty of operation, and it is seldom that satisfactory results have been secured when any considerable acreage is attempted with a number of hand guns. It is a good general rule not to attempt to treat more than about 25 acres in one organization with hand guns, regardless of the number employed, and another good rule is to use hand guns only when no other machine is suitable.

The advantage of hand guns over other types is largely their initial cheapness and adaptability for getting into places inaccessible to larger machines. Furthermore, hand guns are often necessary when the area to be treated is too small to justify the expenditure involved in the purchase of a larger machine.

The disadvantages of the hand gun are that they are exceedingly laborious to operate, and as a result the dusting is often poorly done;

many of them are fragile in construction and thus not sufficiently durable to withstand the hard knocks which they will receive; the operator must walk through the wet cotton, and when the cotton is very tall it is practically impossible to elevate the nozzle sufficiently to reach the tops of the plants. This last difficulty frequently has been overcome by using the hand guns from mule back, and a large amount of very effective dusting has been done in this way.

The various models of hand guns on the market are now offered for sale at from $8 to $18 each. Some of these will last only one season at most, but some of the better types will last for three or four years if given a little attention.

FIG. 2.—Saddle gun attached, ready for cotton dusting.

## SADDLE GUN.

The saddle gun (Fig. 2) is somewhat similar to the hand gun in that it is light and operated by hand cranking, but, as the name indicates, it is designed to be carried on the back of a mule which the operator rides while turning the hand crank, and is usually attached in some way to a saddle. These guns have two nozzles, one extending down on each side of the mule, and it thus treats two rows at a trip. A saddle gun should dust about 15 acres in a day or night of operation, and thus should take care of about 40 to 50 acres of cotton for the season.

The saddle gun can be used under practically any conditions encountered in cotton dusting, is comparatively cheap, and the labor of operation is not great. Furthermore, it is exceedingly mobile and can be taken into places where no machine mounted on wheels could be used. It is not to be expected, however, that it will replace either of the larger types of machines and should be used largely as supplementary to them. So far it has proved impossible to construct

a saddle gun that will create as good a dust cloud as can be secured with the larger machines, and, furthermore, the method of mounting the nozzles makes it very difficult to control their direction readily and thus to secure a thorough dusting of the cotton. In addition, the saddle gun is somewhat difficult to handle in saddling and unsaddling, and is awkward to fill with poison unless the hopper is detachable.

The only guns of this type on the market sell from $55 to $75, but it seems probable that future development will reduce this somewhat.

FIG. 3.—One-mule type of cotton-dusting machine, drawn by a horse, showing general construction.

## ONE-MULE MACHINE.

The one-mule machine (Fig. 3), as the name implies, is drawn by one animal and dusts two rows at a trip. It derives its power from the traction wheels, and the operator walks behind it and usually steadies it by means of handles similar to those of a plow. As a rule it is built so as to work entirely between two cotton rows and has the nozzles extending behind and on each side of the operator. Some models have only one wheel and use shafts in guiding and steadying the machine, whereas others have either two or three wheels. Those with two wheels also have shafts, since their construction is much the same as that of the one-wheel machine. When two wheels are present the distance from outside to outside of the wheels should be not more than 14 inches, and any decrease of this distance is an advantage because it decreases the side sway and also reduces injury to the plant. The three-wheel machines usually have

a singletree hitch and have a castor wheel or shoe in front, which acts as a guide. Since there are no shafts on this machine, it is entirely dependent on the operator to steady it by means of the handles.

The one-mule machines were first placed on the market at the beginning of 1921, and quite a number were used in that year. Of course some difficulties were encountered, but on the whole the splendid efficiency of this type was well proven. One of these machines will dust from 15 to 20 acres in a day or night, and will thus take care of from 50 to 60 acres for the season. It's principal advantage is that it permits simplicity of construction and also that it can be operated in almost any place where a horse or mule can walk. It is easy to turn around stumps and to turn at the row ends. Furthermore, it requires comparatively little artificial light for its operation, since it is practically entirely protected by the animal. The hopper, which holds from 20 to 45 pounds of dust in the different models on the market, does not require very frequent filling, and the labor of operating is not greater than that of any other walking implement. Its disadvantages are that in some places the laborers object to walking, and they are somewhat exposed to contact with the dew-laden plants. In addition, these machines turn over occasionally, but they are usually so constructed that no damage results from this. When a one-mule machine is first operated by a new farm hand it frequently seems cumbersome and difficult to guide, but the same laborer probably had at least as much difficulty the first time he tried to operate a turning plow, and with only a little practice he will be able to guide the one-mule machine with ease.

The machines of this type on the market sell for from $100 to $125 and should last at least five years with reasonably good care.

### CART DUSTER.

The trade term "cart duster" has been adopted to describe the two-horse duster mounted on two wheels, with the driving power for the machinery furnished by these wheels. (Fig. 4.) The axle is of such length that it allows the wheel to run in the center of the rows, and is arched to clear the plants in the row being straddled. As a rule a 42-inch clearance will be found under the arched axle, and this will permit the dusting of plants of any reasonable height. This machine has three nozzles, one over the row being straddled and the others more or less over the rows on each side of the machine. The hopper holds from 25 to 65 pounds of dust in the different models on the market.

One of these machines will treat from 25 to 30 acres in a day or night and thus will care for from 75 to 100 acres for the season. It requires no effort on the part of the operator except to drive the team as he rides in a seat on the platform, and he is not exposed to the wet plants or to the dust cloud. Since the platform is usually about 44 inches from the ground it affords a high mounting for the nozzle, which is an advantage in dusting tall cotton. Furthermore, a barrel of poison can be carried on the platform, making it easy to refill the hopper without dismounting or going out of the field for a supply.

The disadvantages of this machine are that it is somewhat difficult to drive at night and that it requires a rather elaborate lighting equipment. It is also somewhat top-heavy owing to the high-arched axle construction and thus upsets rather easily on uneven or stumpy ground. On the whole this type of machine is best adapted for large open fields clear of obstructions. Numerous models of cart machines are on the market at prices ranging from $200 to $300, and as these are usually of very durable construction they should last for several years.

FIG. 4.—Two-mule or "cart" type of cotton-dusting machine, showing general construction.

## POWER DUSTER.

The power duster consists of a four-wheel wagon with a dusting machine and gasoline engine mounted on the platform, which also carries the lighting equipment, an extra barrel of dust, and two men, one to drive and the other to operate the engine and dusting machinery. This duster, although usually having five nozzles and capable of treating 50 to 60 acres of cotton in a day or night, has not proved generally satisfactory for cotton dusting. It is heavy and cumbersome to handle and can be used to advantage only in very large open fields. The four wheels do much damage to the plants in turning. Then, too, more or less delay is caused by the necessity for repairing the machinery, not only because this type is naturally more complicated in construction but also because the vibration of the engine subjects the entire machine to a strain that is very difficult for such equipment to withstand. These difficulties have proved so serious that this type of machine has been practically taken off of the market. Furthermore, grave difficulties have been en-

countered with the five-nozzle distributing system, since no design has yet been constructed that would give a continuous flow of dust through such a large and complicated distributing system without frequent clogging. In addition, the very width of this distributor makes it exceedingly difficult to handle near obstructions, and frequent breakage results.

## LIGHTING EQUIPMENT.

Owing to the necessity of night operation, the question of lighting equipment is very important; in fact, in the earlier days of dusting the operation was infinitely more difficult than now, because no really satisfactory lighting equipment had been found. Almost every conceivable type of lighting device was attempted and most of them proved unsatisfactory. For example, the various gasoline-vapor lights gave a good illumination, but no mantle would withstand the rough travel over the cotton fields. For the larger machines any type of coal-oil light proved insufficient. Finally, however, a very satisfactory light, using a compressed carbide cake as fuel, was developed. A special model of this light has been constructed for cotton-dusting machines, and is furnished by a majority of manufacturers as standard equipment with the larger machines. It is somewhat expensive, it is true, but it saves many times its cost each year in increased efficiency of operation. Anyone purchasing a cart type of machine is strongly urged to see that it is equipped with such a light at the outset. For the other machines, such as the one-mule and mule-back types, it is not necessary to have nearly such brilliant illumination. During the season of 1921 very satisfactory operation of the one-mule machines was secured by mounting an ordinary coal-oil lantern on them, while with the mule-back guns a carbide headlight, such as is sold for use on bicycles, can be used to advantage. In handgun work it is usually unnecessary to have any special lighting equipment, since most of this work is done in the early morning or late evening; but when such lights are desired, about the best that can be secured is a small carbide light worn on the head, such as is ordinarily sold for hunting purposes. The price of these different lights varies considerably. The large type, such as is used on the cart machine, usually sells for from $30 to $45. The bicycle headlight type can be purchased for from $2 to $3, and a very satisfactory cap light can be bought for about $1.50.

## COST OF OPERATION.

The cost of operating the various dusting machines depends so completely on the conditions on the particular property, the efficiency of operation, the acreage allotments which can be maintained, etc., that it has been found practically impossible to give any definite figures on this subject that have a general value. Furthermore, the cost of the different machines varies widely, as does their durability. In the past it has been rather difficult to calculate the exact machine cost because of lack of definite information on which to base the depreciation charge that should be carried against the different types of machines. Now, however, with longer experience, more or less definite

rules have been adopted by the various farmers engaged in commercial dusting. For example, with the better classes of hand guns it is customary to carry an annual depreciation charge of about 33⅓ to 50 per cent, while with both the one-mule machines and the cart machines a 20 per cent annual depreciation charge appears reasonable. In addition, the question of upkeep enters into the problem, and it is customary to charge from 5 to 10 per cent annually for the upkeep of the one-mule machines and from 10 to 15 per cent annually for the upkeep of the cart machines. This, of course, includes all repairs, adjustments, and replacements. As a rule the total cost per acre per application of the items of machine depreciation, machine upkeep, man labor, and mule labor will be from 20 to 25 cents with either the one-mule or the cart types of machines, whereas with the hand guns it will usually be somewhat higher. The saddle guns have not been developed to the point where any figures of value are available.

## MACHINE OPERATION AND MAINTENANCE.

The best rule for the care and operation of any cotton-dusting machine is the "golden rule of common sense." Almost all of the machines now available will start out and perform efficiently for some time without any care whatever, but no man is going to get his money's worth out of his investment from such treatment of his machinery, and in all probability he will encounter breakdown at just about the crisis of the dusting period, and quite possibly lose the benefit of all that he has done.

When the dusting machine first arrives it should be carefully inspected as it is assembled, to see that every part is properly adjusted and in good working order. See that there is oil or grease where it should be, and that all moving parts work freely with a minimum of friction.

After the machine is started in operation it is a wise plan to inspect it every day before going into the field, as it is much easier to locate and anticipate trouble in daylight than at night when the machine is in operation. This is a case where a stitch in time may save nine times nine. **Above all things keep the machine oiled and greased.**

After the season's work is over, clean the machine thoroughly before storing it for the winter, and give the finished metal parts and chains a light coat of grease to prevent rusting. Blow the air discharge lines clean, and if the machine uses rubber hose see that there are no kinks in this, as these tend to take a permanent set on standing very long. While doing this cleaning watch for badly worn or defective parts, and either repair the old or order new parts immediately, so that the machine will be in first-class condition to start next season's work.

## POISONING DEVICES TO AVOID.

The foregoing pages have outlined the types of poisoning machines found by experience and careful study to yield successful results in the control of the boll weevil. Unfortunately in many cases advantage has been taken of the general interest in the subject

of weevil poisoning to induce farmers to buy substitute devices. The claims made for many of these seem plausible, but a study of their operation easily demonstrates that they are unjustified and the devices worthless or worse.

Many have attempted to control the boll weevil with calcium arsenate by the old "pole-and-bag" method, because they were accustomed to using the pole and bag for dusting cotton with Paris green for the control of the leafworm. The results, however, have been sadly disappointing. In the first place this method could not possibly give the thorough dusting of the cotton plant necessary for weevil control, and the sticky nature of calcium arsenate prevents it from passing through any form of bag in any appreciable quantity.

There are now on the market many devices for attachment to plows, walking cultivators, riding cultivators, etc. These consist usually of some form of shaker or rotating screen device for dropping the calcium arsenate on the plants. Needless to say, any attempt to use such devices is a waste of time and money, although there seems considerable possibility that legitimate dusting machinery may be adapted to attachment to cultural implements. Many other devices for use in somewhat the same manner provide for liquid applications of calcium arsenate or some mixture of calcium arsenate and other products. These have proved equally worthless and should be avoided. Still another type is the machine which purports to permit daytime operation by spraying the cotton with water ahead of the dust cloud. Tests have shown that this style not only fails utterly to create suitable conditions for dusting but that in many cases this application of water to the cotton plants during sunshine, followed by the calcium-arsenate dust, causes sufficient scalding to induce a severe fruit shedding.

It is useless to attempt to list all such worthless apparatus. The foregoing devices, however, are typical, and the best rule is to purchase only real dusting machinery which has had the approval of recognized authorities.

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